

4. Harvesting common reed (*Phragmites australis*) in the Danube Delta Biosphere Reserve: Sustainable Practices and Innovative Technologies for Economic and Ecological Benefits

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Abstract: The Danube Delta Biosphere Reserve in Romania is home to the *Phragmites australis* (Cav.) Steud. or common reed, a valuable resource that is used for various purposes such as habitat for biodiversity, fodder, energy production, construction, and water pollutants treatment. All the Biosphere Reserve territory is organized in order to be concessioned for common reed harvesting. However, the traditional methods of harvesting this plant are used on the edge of territory in the southern part because the transport costs are lower and access to the resource is easy. To ensure the sustainable use of common reed in the Danube Delta Biosphere Reserve, an innovative technology for harvesting is needed. This technology should minimize the negative impacts on the wetland ecosystem, while increasing the efficiency and effectiveness of the harvest even in the frequent flooded areas or directly from open water. This can be achieved through the use of new machinery and equipment, such as specialized boats and harvesters that can cut and collect the reeds and water plant species even without human on board and just using AI.

Furthermore, the use of innovative technologies for common reed harvesting can provide economic benefits for local communities, by increasing productivity, reducing labor costs, and creating new job opportunities. It can also help to address the challenges posed by climate change, as the use of common reed for energy production can contribute to the reduction of greenhouse gas emissions.

In conclusion, the need for an innovative technology for common reed harvesting in the Danube Delta Biosphere Reserve is crucial to ensure the sustainable use of this valuable resource. Such technology should prioritize the conservation of the wetland ecosystem, while also providing economic benefits and contributing to climate change mitigation efforts and benefits for local stakeholders.

Keywords: natural vegetal resources, Danube Delta, harvestable reed, historical practices, innovative products and technologies

INTRODUCTION:

Phragmites australis, also known as common reed, is a perennial wetland grass that is widely distributed across the globe. While it is native to many regions, this species has also been identified as an invasive plant in many parts of the world, causing significant ecological and economic impacts. Invasive *Phragmites* is known to outcompete native vegetation, reduce biodiversity, alter wetland hydrology, and increase the risk of wildfires. (Hazelton et al. 2014) It can also cause economic harm by clogging waterways and reducing the recreational and aesthetic value of affected areas or diminishes the water table in fisheries. (Hakeem, Bhat, and Qadri 2020)

Invasive *Phragmites* is a significant problem in many regions, including North America, Europe, Asia, and Australia. It is particularly widespread in the United States, where it is estimated to have invaded over 4 million acres of wetlands. In Europe, it is recognized as one of the most widespread invasive plant species and is found in many countries, including the United Kingdom, France, and Germany. In Asia, *Phragmites* has been identified as an invasive species in China, India, and Japan, among others. The spread of invasive *Phragmites* is a global concern, and efforts are underway in many regions to control its spread and mitigate its impacts. (Pyšek et al. 2019)

From another perspective, common reed has been traditionally harvested for various purposes by humans, especially in the Danube Delta region, where is still a dominant wetland specie. Its stem, leaves, and roots have been used for thatching roofs, weaving mats and baskets, making paper, and as a source of food and traditional empiric medicine as herb. (Hanganu and Doroftei 2014)

In this paper we focused on Danube Delta historical and actual management practices and made proposals for better solution to improve harvesting, especially in the main – central wetland ecosystem of this territory.

Biology and ecological aspects of common reed (*Phragmites australis*) in Danube Delta – Romania

Phytocenosis dominated by reeds, specifically the *Scirpo-Phragmitetum*, covers a significant portion of the Danube Delta – Romanian territory, spanning approximately 173,000 hectares. Of this area, around 90,000 hectares are characterized by a monodominant reed community. The favorable physical-geographical conditions, including relief, climate, water, and soil, as well as the hydrobiological factors, provide an ideal environment for the growth of this herbaceous associations. This makes the Danube Delta the most extensive and representative region of this type in Europe. (Gastescu and Stiuca 2008)

The common reed is a perennial plant with two distinct parts, an aerial stem that is harvested and a submerged rhizome that penetrates up to 1.5 meters deep into the moist soil or water. The reed stem can reach up to 4-5 meters in height, and it thrives in the fluvial delta along the hydrographic network on gleic or peaty-gleic soils that are temporarily flooded and in the plaur areas. In fluvial delta areas, it is common to find reeds growing alongside or intermingled with *Typha angustifolia* and *Schoenoplectus lacustris*, particularly in locations where mineral sedimentation is active. (Rudescu, Niculescu, and Chivu 1965)

The plaur is a fibric peat formation consisting of viable reed rhizomes with a thickness of 0.8 - 1.5 meters located on an old, more intensively mineralized organic layer or directly on the mineral substrate. The *Scirpo-Phragmitetum* association with tall reeds (3-5 meters) dominates in areas with active circulation of fresh water through plaur, while low reeds (1.5-2 meters) dominate in the marine area where the influence of sea waters is stronger. In the fluvio-marine part of the delta, reeds commonly grow alongside *Carex acutiformis*, *C. riparia*, and *Typha angustifolia*, and the dominant species depends on soil properties. *Salix cinerea* is also often found in association with reeds on the plaur formations. Reduction in reed harvesting and burning for sanitation have led to an expansion of areas covered by sedges, which has resulted in partial destruction of willow trees, bushes and sedges. (Gastescu and Stiuca 2008)

The reeds play an important role in filtering contaminated water and reducing the erosion effects of the river banks caused by water currents along the canals and gullies. They also contribute to the retention of sediments from flood water and have a vital role in the depollution of flood water through their physico-chemical and biological properties. The structure of the phytocenosis includes large amounts of underground biomass represented by roots, rhizomes, and tubers, aerobic-anaerobic interfaces, and an active microbial population present in any humid ecosystem. (Lesage et al. 2007)

The reed beds provide an essential habitat for a variety of bird species, such as the eurasian bittern (*Botaurus stellaris*), eurasian coot (*Fulica atra*), common moorhen (*Gallinula chloropus*), mute swan (*Cygnus olor*) and water rail (*Rallus aquaticus*). The pelican (*Pelecanus onocrotalus* and *P. crispus*), great egret (*Ardea alba*), and purple herons (*Ardea purpurea*) use reeds for nesting, while the coot (*Fulica atra*), cormorans (*Phalacrocorax spp*), terns (*Chlidonias spp.*), and herons use the lakes and water pools in the reeds. (Cramp and Ferguson-Lees 1963; Hanganu and Doroftei 2014)

Plaur and floating plaur islands in the Danube Delta offer a unique habitat for mink (*Mustela lutreola*) and wild boar (*Sus scrofa*), providing a habitat that is difficult to access by common predators. Other animals, such as the otter (*Lutra lutra*), small stoat (*Mustela erminea aestiva*), wild cat (*Felis silvestris*), red fox (*Vulpes vulpes*), raccoon dog (*Nyctereutes procyonoides*), and muskrat (*Ondatra zibethicus*), are also found in the plaur areas.

The reed beds are also significant habitat for fish species in the Danube Delta, where they reproduce and seek refuge during the hot summer months. Thus, perch (*Perca fluviatilis*), silver bream (*Blicca bjoerkna*), common roach (*Rutilus rutilus*), crucian carp (*Carassius carassius*) and tench (*Tinca tinca*) share space in the reeds, while carp (*Ciprinus carpio*), northern pike (*Esox Lucius*), european catfish

(*Silurus glanis*), and common(aral) bream (*Abramis brama*) seek refuge during the summer heat.(Gâstescu and Ştiucă 2006)

Invertebrates such as insects, worms, leeches, crustaceans, and other arthropods provide food for birds, fish, and some mammals. Together with fungi, periphyton, and bacteria, they form an integral part of the detrital food chain. (Hanganu and Doroftei 2014)

Most of this species and taxonomic groups are protected by Natura 2000 European network and other international conventions such as: Convention on Biological Diversity (CBD)- 1992, Convention on Wetlands of International Importance (Ramsar Convention) – 1971, Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) – 1979, Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) – 1992. (Oţel et al. 2000)

MANAGEMENT PRACTICES OF COMMON REED IN DANUBE DELTA

General aspects

Traditionally, reed has been utilized in rural households for various purposes such as construction, fuel, and fodder for animals, particularly during the first growing season. (Hanganu and Doroftei 2014)

In terms of construction, straight reed stems over 2 meters in height and with a diameter exceeding 8 mm are preferred. Reeds from the marine area, which have greater resistance to degradation, are in higher demand as a construction material.

In its biomass form, young reed is commonly used for grazing by cattle and as a source of energy by locals during the cold season.

Reed is also used to create a variety of household items such as carpets, interior decorations, blinds, partitions, fences, and shelves, and it can be utilized as a shade for greenhouses. Depending on the specific needs, braids of different sizes can be made. Additionally, reed is utilized for the manufacture of fascines that protect banks and dikes from erosion. (Hanganu and Doroftei 2014)

Historical facts and common reed harvesting perspective

Reed has been identified as a significant natural resource for the production of cellulose and paper. In the 1960s, an effort was made to understand the biology and ecology of reeds in the Danube Delta due to the abundance of resources available. As a result, the Reed Experimental Station was established in Maliuc under the Ministry of Chemistry to facilitate the controlled cultivation of reeds and to import appropriate harvesting equipment from the former German Democratic Republic. (Rudescu et al. 1965)



a)



b)



c)



d)

Photo 1 Aspects from activity in the Reed Experimental Station established in Maliuc
(screenshots for demonstration purposes only from the propaganda movie “STUF” 1966 - annex 1) :
a) the emblem of the Reed Experimental Station in Maliuc,
b) aspects from experimental laboratory,
c) scientist studying common reed rhizomes,
d) aspects from the library of the Reed Experimental Station - Maliuc

To further capitalize on the production of cellulose from reed, the Cellulose and Paper Factory was constructed in Chişcani, near Brăila. The factory utilized reed sourced from the delta and was transported by barges along the Danube. (Gastescu and Stiuca 2008)



a)



b)



c)



d)



e)



f)

Photo 2: Transport and use of common reed from the Danube Delta in the Cellulose and Paper Factory in Chişcani, near Brăila (screenshots for demonstration purposes only from the propaganda movie "STUF" 1966 - annex 1):

a), b), d) general view and inside Cellulose and Paper Factory in Chişcani aspects paper-sheets coming from production line

c) cranes working in the port for discharging harvested reed and transported by barges e) from the Danube Delta to Chiscani; f) transport of harvested reed by helicopter from isolated spots to barges

Locals and political prisoners were employed as a labor resource for harvesting, packing, and loading the reeds, particularly during the winter months when there was an ice bridge as seen in photo 2.

The reed production line at Chiscani was not designed for woody biomass, but only common reed. Currently, this factory still exists under the commercial name Celhart Donaris SRLs and because of high transport and labor costs is using as raw production material straw from agricultural plants in the Baragan area and/or the used paper.



a)



b)



c)



d)

Photo 2 Aspects from winter time common reed harvesting in 1966, when ice bridge was formed on the lakes and channels due to very low temperatures (screenshots for demonstration purposes only from the propaganda movie “STUF” 1966 - annex 1): a) harvesters gathering and moving towards working areas on the ice bridge of the lakes; b) primitive skates that were mounted on the felt boots used to move faster on the ice or governing the boats sliding on the ice; c) and d) traditional wooden fishing boats „lotca” mounted on custom slides

In the past, fishing was the main activity in the Danube Delta and still is. The fishermen were using for transport traditional wooden boats called „lotca”. During wintertime when lakes and channel were frozen, this traditional wooden fishing boats was also mounted on custom slides and used as cargo for reed transport. In order to move faster a sail was mounted to use wind power and people whit skates stay in the back of boat to proper govern it.

The use of inappropriate harvesting equipment (that was using iron crawler lane) in environmentally sensitive areas has caused damage to the rhizome layer and degradation of the reed beds, resulting in a gradual reduction of the harvested reed biomass.

This has led to a significant decrease in reed mass volumes from around 240,000 tons in the 1960s to just a few thousand tons presently.



a)



b)



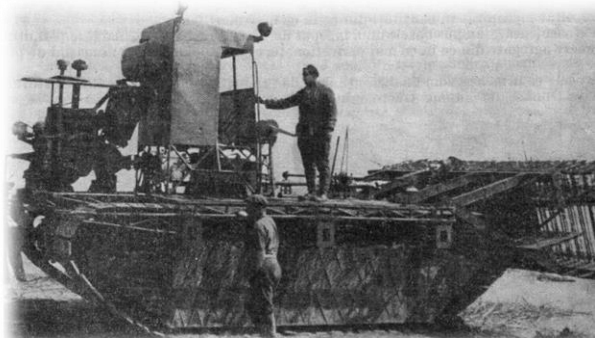
c)



d)



e)

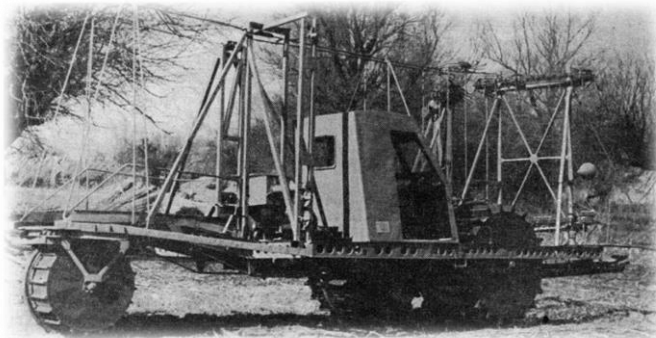


f)

Photo 3 **Common reed harvesting equipment used in 1960's** (screenshots for demonstration purposes only from the propaganda movie "STUF" 1966 - annex 1):
a), b), c), d), different aspects from using in the field of the common reed harvesters – Romania production adapted from German Democratic Republic technology
e), KDS harvester and f) IPROM harvester – Romanian adapted technologies – using iron crawler lane (Rudescu et al., 1965)

In the 1960's the use of adapted reed harvesting machineries from German Democratic Republic did not take in account one aspect. In the Danube Delta the ground that common reed is found is a soft muddy substrate mostly resulting from aquatic plants decomposition, whereas in Germany the ground is sandier and firmer, hard. Many reed harvesters sunk in the mud and never have been recovered, therefore in 1970's a new solution was adopted – big wheels whit low pressure rubber types, less than 100 gr/cm².

This equipment had a better capability, even fall in water, can float and crawl out on the firm ground or muddy areas of marshes from the Danube Delta.



a)



b)

Photo 4 **Common reed harvesting equipment used in 1970's** (Rudescu et al., 1965)

a) Harvester using drums, b) light harvester on low pressure tires

Nowadays, in Germany the harvesting equipment is still based on crawler lane but whit rubber bumpers that is more friendly whit the reed rhizomes. The substrate and lake bottom in these areas is sandy and not muddy - therefore the equipment is not damaging the reed rhizomes and the risk to get stuck is minimal.

Actual approach

The universal value of the Danube Delta Biosphere Reserve has been recognized through its inclusion in the international network of biosphere reserves under UNESCO's "Man and Biosphere" program in 1990. The reserve was acknowledged as an internationally important wetland area, particularly for waterbird habitats, under the Ramsar Convention in September 1991. Furthermore, the Delta was acknowledged as a natural and cultural heritage site of universal value and was added to the World Heritage List in December 1991. The effectiveness of the ecological management plan applied within the Danube Delta Biosphere Reserve and its natural heritage value were recognized through the European Diploma for Protected Areas, initially awarded in 2000 and renewed in 2005, 2010, and 2020. Additionally, the inclusion of the Danube Delta Biosphere Reserve and the Danube Biosphere Reserve in Ukraine in the international network of transboundary biosphere reserves Romania-Ukraine was made in 1999. (Anon n.d.; Centre n.d.)

Nowadays, reed harvesting is done respecting all the regulations that are in role for this territory because of above multiple status of international and national value.

Therefore, the reed harvesting is permitted for local population household needs – build up or reconstruction of traditional houses whit reed roof, traditional reed fences, animal shelter, small lightweight storage in the yards or even fisherman small shelters from outside the localities needed to guest professional fisherman's during their weekly activity. The harvested reed for local population family's needs is not to be sold or commercially capitalized. The right to harvest reed in this case, is approved following an official request to the Danube Delta Biosphere Reserve Authority and a small fee.

The common reed harvesting is also permitted for commercial stakeholders such as local associations, small enterprises or juridical approved bodies based on concession contracts.

This concession is done only inside established areas that comprises almost the entire territory of the Danube Delta Biosphere Reserve. In the 1990, the number of this areas started whit 12 in 1990, and nowadays reached 19 areas, showed in the map from Annex 1.

Some of the areas are too big for the companies or locals to be economically profitable, therefore, based on the D.D.B.R.A evidence, only southern proposed areas are frequently harvested, whereas the inner delta territory is not concessioned for harvesting.

Because the main quantity of harvested reed is going on export for thatching, the interest is to have a quick modality to pack and transport the harvested reed on trucks and not naval intermediate transport that rise its final price. This can be done efficiently in the closest areas to roads situated in the southern part of the delta territory.

Nowadays, reed harvesting companies are using only approved harvesters that are not damaging common reed rhizomes or cause substrate subsidence/damage.



Photo 5 – Reed harvesters used nowadays in Danube Delta Biosphere Reserve territory, equipped whit low pressure tires

One of the needs to motivate the common reed harvesting inside the main Danube Delta Biosphere territory is to diversify products that can be obtain from the raw biomass and this can lead to also maintain the reedbeds in a good ecological status and not increase the propagation of the other vegetation types especially willow bushes or even progressive accelerated terrestrialization vegetation such as floodplain forests.

Besides harvesting reed as a resource, another aspect is to maintains small narrow channels that are used by local fishermen as shortcuts to the fishing areas. These channels are fast overgrowth by *Phragmites* and became impracticable. Fishermen have to go around, loose time and pollute or disturb nature using longer time the boat engines.

Danube Delta Biosphere Reserve Administration have no permanent service for maintenance of such small channels if this are closing because of vegetation development (mainly common reed) or even an old tree falls down and block the channels.

New proposals

Recently, there has been increased interest in developing innovative products from *Phragmites* that have the potential to create economic opportunities while also promoting the conservation and restoration of wetland habitats.

One such innovative product is *Phragmites* biocomposite materials. This type of biocomposites is made by combining the fibers of the plant with a biodegradable resin, resulting in a lightweight and durable material that can be used in a variety of applications, including furniture, flooring, and building materials. *Phragmites* biocomposites offer a sustainable alternative to traditional materials such as plastics and synthetic fibers, which can have significant environmental impacts.

Another innovative product that can be obtained from *Phragmites* is biochar. Biochar is a type of charcoal that is produced by heating organic materials, such as *Phragmites*, in a low-oxygen

environment. It can be used as a soil amendment to improve soil health and fertility, as well as a filter media to remove contaminants from water and air. Biochar production from *Phragmites* also has the potential to provide an additional revenue stream for wetland conservation and restoration efforts.

Common reed also has potential as a source of bioenergy. The plant can be harvested and used as feedstock for biofuels, such as ethanol and biogas. While commercial-scale production of biofuels from *Phragmites* is still in the early stages of development, it holds promise as a renewable energy source that can contribute to reducing greenhouse gas emissions and promoting sustainable development.

During a pilot project: “Development of innovative technologies using artificial intelligence for the valorization of biomass from lake areas for the sustainable support of green energy”, good results were obtained in developing above mentioned products some of them being under patent certification: phytosilicate, bioethanol, biochar, hydrogen.



Photo 6 Different pilot results obtained in a pilot project that used *Pragmites* biomass as raw material

- a) Electrolyze device – 1000ml – patent pending; b) biochar; c) bio-stimulant material for agriculture patent pending

The same project has developed and tested a floating harvester intended to be used to harvest vegetation biomass such as palustrine vegetation (*Phragmites*, *Typha*, *Carex*) or underwater macrophytes that usually develop in fish farming ponds, natural lakes, or channels, that is shown in the below photo.



a)



b)

c)

Photo 7 The floating experimental harvester “ERBA” developed within project: “Development of innovative technologies using artificial intelligence for the valorization of biomass from lake areas for the sustainable support of green energy”

- a) harvester view from the back when in work towards harvesting palustrine vegetation,
- b) view from the front of the floating harvester in autonomous mode,
- c) floating harvester in un-manned mode piloted using a remote.

The floating harvester was designed to use electric propulsion and have a possibility to be manipulated using a remote control. In the advanced prototype design a module of Artificial intelligence component was included. In this case, based on drone survey, the harvester can work and take actions independently. Due to legislative safety restrictions a person has to attend and manipulate the harvester in case of a malfunction or error.

This innovative solution was intended for cleaning the lakes of excess biomass, which poses serious problems to the managers of the lake and recreational lakes, but it can be used as well in fish farming or natural water bodies of Danube Delta Biosphere Reserve.

CONCLUSIONS

The role of an efficient natural protected management is to find suitable solutions to keep and maintain balance between nature conservation and on the other hand respect traditions and local population in one unique area of Romania and Europe, that is Danube Delta Biosphere Reserve.

However, the commercial harvest of *Phragmites* is currently limited due to the difficulty of large-scale processing, limited market demand, and potential negative impacts on wetland ecology if not closely supervised.

The management of *Phragmites* as a harvestable resource must balance the need for conservation and the preservation of wetland ecosystems with the sustainable use of this natural resource. Efforts are underway, whit already existing pilot results, to develop sustainable harvesting practices and to create markets for *Phragmites* products that support the conservation of wetland habitats and the livelihoods of local communities.

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ANNEXES

Annex 1

Screenshots from the propaganda movie “STUF” – in translation “THE REED” 1966, archive digital copy, production of cinematographic studio “Alexandru Sahia” from Bucharest.



Even such material was made for the showing to the locals and population inside Romania during communism to raise the morale and promote “great achievements” of the Communistic party, they also include valuable illustrative material to understand the level of scientific approaches and their implementation.

Annex 2 The map of potentially common reed harvestable areas of The Danube Delta Biosphere Reserve territory in 2022 – 2023 harvesting season

